



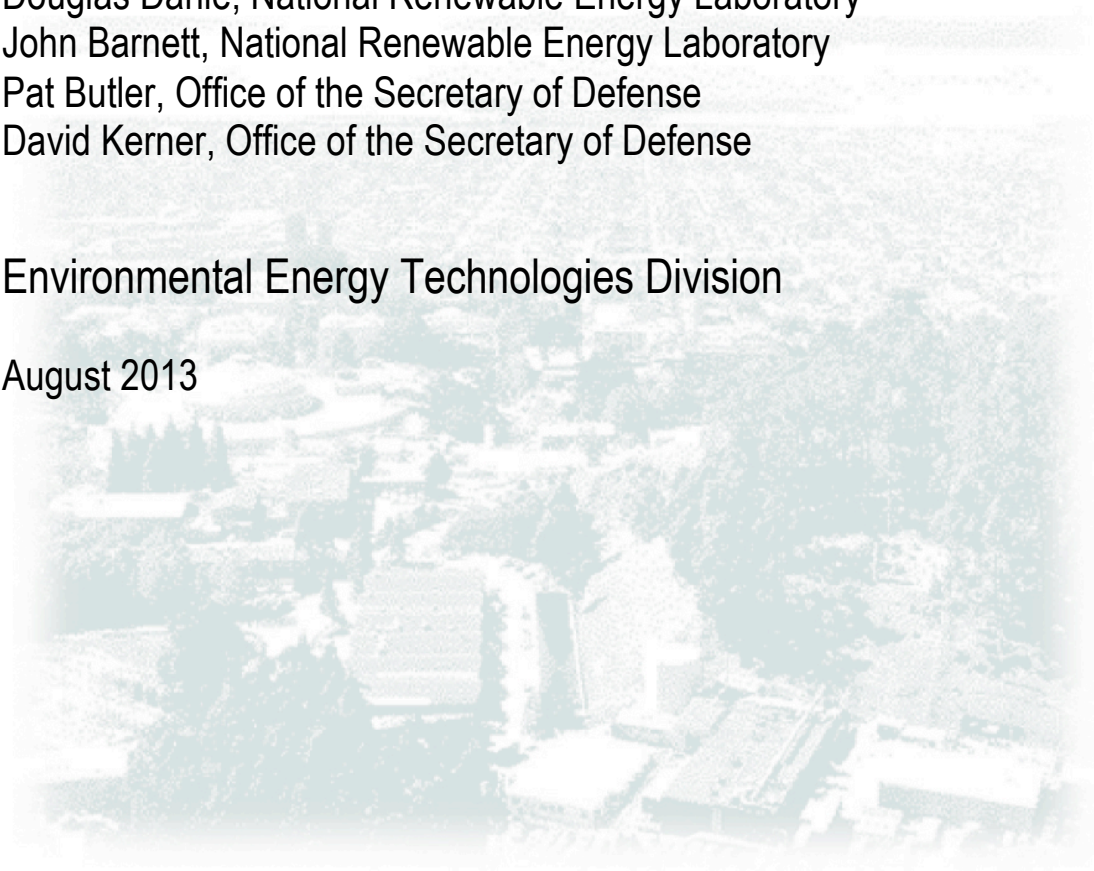
ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

Potential for the Use of Energy Savings Performance Contracts to Reduce Energy Consumption and Provide Energy and Cost Savings in Non-Building Applications

Charles Williams, Lawrence Berkeley National Laboratory
Andrew S. Green, Lawrence Berkeley National Laboratory
Douglas Dahle, National Renewable Energy Laboratory
John Barnett, National Renewable Energy Laboratory
Pat Butler, Office of the Secretary of Defense
David Kerner, Office of the Secretary of Defense

Environmental Energy Technologies Division

August 2013



DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor The Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or The Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or The Regents of the University of California.

ACKNOWLEDGMENT

This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Federal Energy Management Program, of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

Table of Contents

I.	Executive Summary	1
A.	Findings	1
B.	Background	2
C.	Study Objectives	2
D.	Potential Savings in Non-building Applications.....	2
E.	Feasibility of ESPCs	6
II.	Introduction.....	7
A.	Statement of Task	7
B.	Background and Context.....	8
1.	Overview of Non-Building Federal Energy Use	8
III.	Estimate of Potential Savings in Non-Building Applications.....	9
A.	Military Applications –Summary of Recent Studies on Weapons Platforms.....	11
1.	Aircraft.....	12
2.	Ships	19
3.	Land Platforms/Vehicles	22
4.	Tactical / Mobile Power Generation.....	23
B.	Federal Civilian Agency Applications.....	23
1.	Fleets/Trucks	25
2.	Ships	26
3.	Aircraft.....	26
4.	Water Transport/Irrigation.....	27
C.	Secondary and Environmental Savings	28
1.	Secondary Savings Opportunities.....	28
2.	Environmental Savings Opportunities.....	29
IV.	Feasibility of Extending the Use of Energy Savings Performance Contracts to Non-Building Applications	29
A.	Measurement & Verification (M&V)	30
1.	Performance M&V	30
2.	Maintenance, Labor and Material M&V	32
B.	Guaranteed Savings	32
1.	Risk/Responsibility.....	32
C.	Applications Not Feasible Under Existing Legislation	33
D.	Implementation Challenges	34
Long term payback	34	
Funding Transfers	34	
V.	Findings	34

APPENDIX A – Study Authorization - Text

APPENDIX B– History of ESPC in Federal Buildings

I. Executive Summary

A. Findings

The findings of this study indicate that potential exists in non-building applications to save energy and costs. This potential could save billions of federal dollars, reduce reliance on fossil fuels, increase energy independence and security, and reduce greenhouse gas emissions. The Federal Government has nearly twenty years of experience with achieving similar energy cost reductions, and letting the energy costs savings pay for themselves, by applying energy savings performance contracts (ESPC) in its buildings. Currently, the application of ESPCs is limited by statute to federal buildings. This study indicates that ESPCs can be a compatible and effective contracting tool for achieving savings in non-building applications.

In order to use this contracting method, modifying language and definitions in the current legislation, 42 U.S.C. § 8287, to accommodate non-building applications would be necessary. A summary of potential changes to 42 U.S.C. § 8287 include the following:

- Add a new section authorizing ESPCs for non-building applications
- Amend language to allow payments by an agency to include savings in fuel use
- Add definitions of “non-building applications” and “secondary savings”
- Amend the definition of “energy savings” to include non-building applications
- Amend the definition of “energy savings” to include savings from reduced fuel use.

Specific recommended language revisions and amendments to the existing legislation are delineated in Section V of this study.

There are some important differences between investing private capital in operational assets via ESPC compared to fixed facilities:

- Individual buildings can be upgraded as individual projects. Operational systems are generally part of a fleet, and upgrades are best accomplished on a fleet-wide basis.
- Since 1997, Federal agencies have invested over \$6 billion for facility energy upgrades through the ESPC program. A single project to upgrade an operational system could exceed that figure. Re-engining a single airframe such as the B-52, for example, could cost nearly \$10 billion.
- Investments in operational systems are at different risk than investments in fixed facilities. Fixed installations are stationary while operational systems move into harm’s way. After more than a decade at war many vehicles and a number of rotary wing aircraft have been lost. Fixed installation ESPCs commonly feature evaluation of expected useful life of equipment; the risk factors of operational equipment would need to be similarly accounted for.
- To determine the payments to be made under the program the amount of energy cost saved must be calculated. The government has years of experience measuring and verifying energy savings for buildings but needs to develop methodologies and gain experience for doing it in mobile systems.

- Since operational systems are more highly integrated, a higher degree of design work is necessary, and the work must generally be done by the original equipment manufacturer. There are exceptions for work done in military industrial depots.
- Finally, when the ESPC program was initiated in 1988, it was as a pilot program for a limited period of time. A similar limited time and cost pilot may be worth considering for expanding the authority to mobile systems in order to ascend a learning curve and manage financial risk as procedures are developed, exercised and validated.

B. Background

The National Energy Conservation Policy Act authorizes federal agencies to enter into ESPCs for the purpose of achieving energy and water savings, in which a contractor is to be paid based on the realized savings. (42 U.S.C. 8287 *et seq.*) “Energy savings” is defined so as to limit the applicability of ESPCs to federally owned buildings. (42 U.S.C. 8287c(2)). Historically, ESPCs have allowed federal agencies to install and maintain energy efficiency improvements in federal buildings in the absence of capital appropriations. Section 518 of the Energy Independence and Security Act of 2007 (EISA 2007, Pub. L. No. 110-140) directed the Secretaries of Energy and Defense to conduct a joint study to examine the potential use of ESPCs to provide energy and cost savings in *non-building applications* including vehicle or other mobile assets. This study was prepared in coordination with the Department of Defense by the Department of Energy’s Federal Energy Management Program, the lead agency that has designed and implemented Federal government facility (building) ESPCs for the past 15 years, implementing over \$6 billion in energy savings investments.

C. Study Objectives

This study explores potential energy and cost savings in non-building applications, which could include military fleets and weapons platforms, other federal agency fleets and non-building assets such as electric generation and water transport facilities. It determines the potential dollar value of possible energy-saving investments by reviewing recent studies on improving energy efficiency in non-building applications. The study also assesses the feasibility of extending the use of ESPCs to energy-saving investments in non-building applications.

D. Potential Savings in Non-building Applications

The military has the largest potential for savings in non-building applications because of its fuel-intensive activities in air, sea and land supply, support and combat missions. The DOD determined that it represents 1.2 percent of total U.S. fuel use and that fuels for aircraft, ships, and vehicles account for 74 percent of total DOD use. Studies, over the past decade, including several by the Defense Science Board (DSB), have investigated ways to modernize and reduce energy use for a variety of weapons systems. This reflects a growing awareness within the DOD of the impact of accelerating energy costs on the

Armed Services' war fighting capabilities. In many instances these studies concluded that increased energy efficiency in weapons platforms also increases mission capability.

Table 1 provides an overview of findings in previous reports that include only applications that have defined quantifiable savings and capital costs. Limited implementation of these identified technologies has been undertaken. Applications listed are modernizations and retrofits that may have the potential to produce substantial savings and represent possible ESPC candidates, where cost savings could be used to finance capital investment. They represent only a sample of what is possible. Overall, estimated savings generated from projects identified by these studies amount to approximately \$1 billion per year from a total project investment of \$7-10 billion.

Table 1: Sample of Potential for Non-Building Applications of ESPC

Application	Agency / Dept.	Paid-by-Savings Investment Potential
Fuel Efficient Coatings for Ground Vehicles: Engines, transmissions and differentials.	Most DOD and civilian agencies	\$9-10M
Fuel Efficient Propeller Coatings, Bulbous Bow hydrodynamics, Ship Hotel Load Efficiency, Ship High Efficiency Gas Turbines	Navy / Coast Guard	\$595 – 895M
Re-engining TF33 Aircraft engines found on KC-135E, E3 AWACS, E-8 JSTARS, and B52H airframes; Aircraft Wingtip Modifications on KC-10 & KC-135 airframes	Air Force / NASA	\$6.4 - 8.7B
Abrams M1A1 / M1A2 Auxiliary Power Unit.	Army	\$300M
		\$7.3 – 9.9B

Potential applications of ESPCs for non-building assets among civilian federal agencies are less common and substantial than among military weapon systems and mobility assets. This may be attributable to the use characteristics of weapon systems – unlike civilian vehicles, they are intended for readiness for potential conflict rather than routine and steady use, and therefore have extended useful lives during which major advances in efficiency and propulsion may occur. Also, the number of studies on energy efficiency in weapons system indicates awareness within DOD of the impact that accelerating energy costs has on war fighting capabilities.

There are notable exceptions on the civilian side, however. Though no studies were found that estimated potential energy cost savings from civilian fleets, significant savings may be realized for civilian agencies with aircraft, ship and heavy vehicle fleets by implementing retrofits and technology applications similar to those identified for military fleets (see Table 1).

Other exceptions, some of which are not mobile assets, include the large potential for efficiency improvements in power generation at federal hydroelectric facilities. The majority of federal hydroelectric dams are operated by the Army Corps of Engineers (USACE) and the Department of Interior's (DOI) Bureau of Reclamation (BurRec). At an average age of 50 years, most of these facilities are operating well beyond their intended design life of 35 years. Hydroelectric turbine and generator technology has advanced to provide 40% more power production at the same water flow rate. Upgrading older turbines also yields additional benefits such as reduced maintenance and repair costs and increased dissolved oxygen levels from turbine discharge. Current low dissolved oxygen levels cause seasonal cutbacks on power generation to allow for fish spawning and migrations. New aerating turbines may substantially mitigate this problem, allowing for more continuous operation.

The results of a May 2007 study authorized by Congress estimated that nearly 1,300 MW of additional capacity is possible through upgrading existing hydroelectric generation units. This translates to adding over 3,900 GWh/year through rehabilitation projects.

Based on a project analysis conducted by the U.S. Army Corps of Engineers (USACE) for one dam, a \$56 million re-powering investment could yield annual energy cost benefits of \$5.8 million, as well as \$1 million per year in reduced repair costs. The result is a simple payback of eight years, well within current terms for ESPCs.

The U.S. Coast Guard (USCG) operates the largest federal civilian ship fleet. Larger Coast Guard cutter ship classes would likely benefit from “hotel” load, propulsion system and hull retrofits that are applicable to U.S. Navy ships. Propeller/shaft coatings and hull modifications such as bulbous bows reduce fuel use and increase range. These retrofits have short payback periods and could be good ESPC candidates. “Hotel” loads (e.g., HVAC, kitchens and electronics; note p. 19 below) alone on Coast Guard cutters can be substantial – so much so that the “cold iron” load when a vessel is docked, using power from shore rather than its on-board generators, can be the largest single electrical load at a Coast Guard base. ESCOs implementing ESPCs at USCG facilities have proposed such retrofits, but it has not been legally possible to proceed because of the statutory limitation to buildings.

USCG and the National Aeronautics and Space Administration (NASA) operate the largest aircraft fleets outside the DOD. The fleets comprise over 20 classes of fixed wing aircraft ranging from small four-seat prop aircraft to large airframes such as the DC-8, 727, C-17, and 747s. Further investigation is required to determine the number of planes expected to remain in service over the next 20 years, which would help determine the magnitude of opportunities for potential retrofits such as engine replacement or wingtip modifications. Ships and aircraft operated by the National Oceanic and Atmospheric Administration may also benefit from authorization of ESPC for mobile assets.

Significant secondary savings may be associated with non-building energy efficiency applications from impacts on indirect energy use, personnel, materiel, and operations. Indirect energy use may arise from logistical support associated with the primary users, particularly in the military context. For example, when the Army deploys into a theatre of operations, over 70 percent of the gross tonnage moved is fuel. Fifty-five percent of the fuel the Army takes to the battlefield does not go to front-line combat units; it is consumed by the logistics tail and its protection. The Army spent \$200 million on fuel in FY 2000) but paid \$3.2 billion a year to maintain 20,000 active and 40,000 reserve personnel to move that fuel. Similar examples may be found throughout the military services, including for refueling of ships underway, or in-flight refueling of aircraft.¹

In addition to savings from reduced indirect energy use, there may also be cost savings from reduced personnel requirements, which can lower the total number of required personnel (e.g., from the estimated 60,000 total active duty and reserve Army personnel cited above) or permit shorter or less frequent personnel deployments. Materiel costs may also be reduced by measures that decrease maintenance requirements and increase materiel lifetime, delaying costly replacements. A prominent example is the frequently studied potential replacement of TF33 jet engines on B-52s, JSTARS and other large aircraft. These engines must be removed from the aircraft and completely overhauled four to six times more often than equivalent modern commercial jet aircraft engines.

¹ 20001 Defense Science Board Report “*More Capable Warfighting Through Reduced Fuel Burden*”, Chapters III and IV

Finally, there may be operational implications that directly affect the ability to perform certain military or non-military missions. For example, increased range for any form of mobility can permit missions that are longer in duration or further in distance; not only may associated logistics support costs be reduced, but freedom to perform completely new missions may result.

The more efficient use of fuel should translate into emissions reductions, including those that contribute to pollution of the local environment, and those that contribute to climate change. Environmental savings are more difficult to estimate. However, as more certainty is developed in assigning economic values to emissions, such savings could be considered as a component of energy savings.

E. Feasibility of ESPCs

The key element of ESPCs that differs from conventional government contracting is that ESPCs are paid for from future savings guaranteed by a contractor, and therefore incorporate a debt instrument that capitalizes the future savings stream. It is necessary to establish a baseline of current and projected future energy and operating costs from which future savings will be calculated in order to establish the terms of the guarantee of those savings (i.e., who is responsible for foreseen and unforeseen variables that may affect those future savings), and to establish methods through which savings will be measured and verified to confirm that the terms of the guarantee are being met.

These contract elements and the procedures through which they are implemented are well established and continually improving in the ESPC industry for buildings. Federal practices for buildings ESPCs are developed and “routinized,” with guidelines based on federal procurement law and more than a decade of experience. ESPC for non-buildings opportunities would share the vast bulk of these practices, but there are salient areas of potential differences in non-building applications – some which could make ESPC potentially easier to implement, and others which might present challenges – that would need to be addressed.

Baseline and operational energy costs of combat systems (e.g., weapons and mobility platforms), which constrain where, when, and how ESPCs can be applied, may be difficult to establish. Besides the unpredictable effect of combat conditions that cause equipment and system failure or loss, many combat systems are used at highly variable rates, ranging from storage mode to full-time deployment. Programs to use private funds to upgrade these systems must accommodate the likelihood that systems may either be lost to combat or become unusable prematurely, sometimes significantly so, due to high tempo operations in harsh environments. Under these conditions an ESPC contract could create “must pay” bills that might not be matched by savings if projected equipment life is not accurately estimated to account for potential risk. Moreover, a major driver of energy costs lies not in the direct point of fuel consumption, but in the indirect costs of

delivering the fuel to where it is needed, the logistics attendant to that supply chain, and the mission tactics associated with a given vehicle's range.² These factors all make it challenging to characterize "average" energy use profiles and to develop a realistic contracting strategy for quantifying and capitalizing energy savings – particular in the ESPC context of guaranteed savings.

As each individual building ESPC task order must result from careful negotiation of terms and responsibilities for the unique circumstances of each project, the exact details of each non-building ESPC would have to be worked out on the basis of the specific facts of that application. The review of potential challenges within this report suggests that, while the same care must be exercised as in every prudent government acquisition, there appear to be no insurmountable challenges to using ESPCs to capture the savings potential of non-buildings applications.

II. Introduction

A. Statement of Task

Section 518 of the Energy Independence and Security Act of 2007 (EISA 2007; Pub. L. No. 110-140), directed the Secretaries of Energy and Defense to "jointly conduct, and submit to Congress and the President, a report of, a study of the potential for the use of [ESPCs] to reduce energy consumption and provide energy and cost savings in non-building applications."³ This study is in response to that direction.

As directed by section 518 of EISA, this study:

1. estimates the potential energy and cost savings to the Federal government, including secondary savings and benefits, from increased efficiency in non-building applications; and
2. assesses the feasibility of extending the use of ESPCs to non-building applications.

For the purposes of this study, "non-building application" is defined as:

1. any class of vehicles, devices, or equipment that is transportable under the power of the applicable vehicle, device, or equipment by land, sea, or air and that consumes energy from any fuel source for the purposes of
 - a. that transportation; or
 - b. maintaining a controlled environment within the vehicle, device, or equipment; and
 - c. any federally owned equipment to generate electricity or transport water.

Also for the purpose of this study, "secondary savings" is defined as:

²Paul Dimotakis, Nathan Lewis, Robert Grober, et al., "*Reducing DoD Fossil-Fuel Dependence*", JASON for the Director of Defense, Research & Engineering. September, 2006

³ Section 518(b) of EISA 2007.

1. energy and cost savings that result from a reduction in the need for fuel delivery and logistical support;
2. personnel cost savings and environmental benefits; and
3. in the case of electric generation equipment, the benefit of increased efficiency in the production of electricity, including revenues received by the Federal government from the sale of electricity so produced.

B. Background and Context

1. Overview of Non-Building Federal Energy Use

Although the federal government has had success in meeting past energy-use reduction goals, it is estimated that it still has the potential to save over \$1 billion each year on its buildings' energy use.⁴ But there is an even greater opportunity to both reduce energy consumption and to replace obsolete equipment that remains entirely left on the table – and that is the energy savings opportunities in non-building applications: in “mobility” assets like transportation fleets and DOD weapons platforms, in aging hydro-electric power plants and water pumping stations, and other non-building assets. Federal energy use for transportation and fleets is far greater than that for buildings, and in many cases, the savings opportunities are larger. Numerous recent studies summarized in this report have documented savings opportunities running into billions of dollars annually. The Department of Defense, the individual Armed Services and related institutions like the Defense Science Board have in recent years acknowledged and acted upon the importance of fuel costs and fuel efficiency to war-fighting capabilities, and analyses of fuel and cost-savings opportunities have been numerous for mobile weapons platforms. While a modest amount of non-buildings energy savings opportunities have been implemented through investments of appropriated funds, it is, like in the buildings sector, only a fraction of what is attainable.

ESPCs in the federal building sector have been operational for almost two decades. Scores of contracts have provided more than \$6 billion in efficiency investments, with over \$1 billion more now in development, and they are the primary vehicle that has allowed progress in reducing federal energy use in buildings (see History of ESPC, Appendix A). With guarantees of energy savings, federal agencies use these contracts to pay for infrastructure upgrades without utilizing capital appropriations. Application of ESPCs to non-buildings could provide opportunities to reduce operational costs in that sector to be converted to capital investments – at no additional upfront capital cost to the taxpayer. The energy-savings opportunities for non-building applications of ESPCs include upgrading aircraft, naval vessels, land-based weapons platforms (e.g., tanks), and other opportunities to modernize capital infrastructure that could be achieved without competing for appropriated dollars.

⁴Alliance to Save Energy; Fact Sheet; May 2005.

The U.S. federal government is the world's single largest consumer of energy, and has the largest potential to save energy and costs. Federal agencies account for 1.5 percent of the country's total energy use, at a cost to U.S. taxpayers of \$17.1 billion (FY07). Of this total, 36.1 percent (~\$6 billion) goes to heat, cool, and power the approximately 500,000 federal buildings around the country. 63.9% of federal energy use is for non-building purposes. This includes fleet vehicles, military aircraft and ships, and a variety of mobile systems that must be deployed and fueled wherever they are needed, for defense, disaster relief and recovery, scientific research, and a host of other federal responsibilities.⁵

Nearly two-thirds of the federal potential to convert potential energy savings into capital for improvements, therefore, is thus untouched by present statutory authority. A January 2001 Defense Science Board Task Force Report⁶ underscored the opportunities in mobile weapons platforms, and encouraged expansion of ESPC to capture these opportunities. Notable observations included:

- more than 70 percent of the tonnage required to position today's U.S. Army into battle is fuel;
- for its airborne refueled aircraft fleet, the Air Force spends approximately 85 percent of its fuel budget to deliver fuel by airborne tankers and just 6 percent of this budget, for its annual jet fuel usage;
- the Task Force further found that high pay-off, fuel efficient technologies are available now, and recommended that DOD specifically target fuel efficiency improvements.

2. Legislative History

The concept of using ESPC to capture mobile or non-building savings opportunities was included in Senate language for a 2003 Energy Policy Act for the purpose of achieving energy or water savings, secondary savings, and benefits incidental to those purposes, in non-building applications.⁷ A 2003 bill ultimately was not passed in the same form by both houses.

III. Estimate of Potential Savings in Non-Building Applications

5. Annual Report to Congress on Federal Government Energy Management and Conservation Programs Fiscal Year 2007; U. S. Department of Energy, Federal Energy Management Program; January 27, 2010.

6. "More Capable Warfighting Through Reduced Fuel Burden" The Defense Science Board Task Force on Improving Fuel Efficiency of Weapons Platforms, January 2001, Office of the Undersecretary of Defense for Acquisitions, Technology and Logistics; WashingtonDC20301-3140

⁸ Ronald O'Rourke, Foreign Affairs, Defense, and Trade Division, Congressional Research Service, CRS Report for Congress, "*Navy Ship Propulsion Technologies: Options for Reducing Oil Use – Background for Congress*", December 11, 2006.

Studies completed since the DSB report, and summaries compiled by the Office of the Secretary of Defense, document opportunities in DOD alone to convert potential energy cost savings into productive infrastructure improvements. Table 2 summarizes recent findings. Metrics differ, and limited applications of selected technologies have been undertaken. However, the potential dollar volume identified in existing studies alone exceeds the \$6 billion of the past twenty years of buildings ESPCs.

Table 2: Summary of Potential for Non-Building ESPC Applications

Application	Agency / Dept.	Capital Costs	Benefits/Savings	Report Referenced	Estimated Aggregate Investment Potential
Fuel Efficient Coatings for Ground Vehicles: Engines, transmissions and differentials.	DOD, truck fleets in civilian agencies	\$400/vehicle	<ul style="list-style-type: none"> 3% improved performance 10% decrease in fuel use Reduced maintenance Saves 22M gal & \$46M/yr ROI is 37% 	Presentation, "Energy Options" Department of Defense, 3/17/2008	\$9-10 M
Fuel Efficient Propeller Coatings	Navy / USCG	\$200k/ship	<ul style="list-style-type: none"> 5-6% fuel savings or \$140M/yr less fuel costs. Reduced wear & tear Lower Maintenance < 1yr payback 	Presentation, "Energy Options" Department of Defense, 3/17/2008	\$15 M
Bulbous Bows on ships for improved hydrodynamics	Navy / USCG	\$380k/ship.79 ships fitted for \$30 million in 2000	<ul style="list-style-type: none"> Arleigh Burke Class Destroyer saves 3.9% in fuel or 2,400 bbl/yr. Partially implemented in Navy Fleet. 	CRS Report for Congress, "Navy ship Propulsion Technologies" Dec. 11, 2006	\$30 M
Navy Ship Hotel Load Efficiency	Navy / USCG	\$3M - \$7M/ship	<ul style="list-style-type: none"> \$1million/Ship-yr (Aegis Cruiser Class) 10 to 25% fuel savings Increased range 	DSB Task Force, Rocky Mountain Institute.	\$400 M
Ship Hotel Loads – Higher Efficiency Gas Turbines	Navy / USCG	- Variable -	<ul style="list-style-type: none"> 25%-30% less fuel use \$1.5 Million/Ship-yr Greater range 2-6 year payback on premium over original 	CRS Report for Congress, "Navy ship Propulsion Technologies" Dec. 11, 2006	\$150 – 450M
Re-engining TF33 Aircraft engines found on KC-135E, E3 AWACS, E-8 JSTARS, and B52H airframes,	Air Force / NASA	B52 Fleet: \$3.2B	<ul style="list-style-type: none"> NPV: \$264M Based on DESC fuel costs 46% increase in range Reduction in Tanker Aircraft needed. Increased loiter time. 	NPS-FM-06-034, "Using Public-Private Partnerships and Energy Savings Contracts to Fund DoD Mobile Assets", 9/30/06	\$6-8B
Aircraft Wingtip Modifications on KC-10 & KC-135 airframes	Air Force / NASA	Per Plane KC-135's: \$500k - \$1m KC-10's: \$1.5 – 3.0M	Fuel costs savings per plane KC-135's: \$80k-\$130k KC-10's: \$250k – \$410k	"Assessment of Wingtip Modifications to Increase Fuel Efficiency of Air Force Aircraft" NAS, 2007	\$350 – 700M
Abrams M1A1 / M1A2 Auxiliary Power Unit.	Army	\$300M	<ul style="list-style-type: none"> \$78M per year, fully burden fuel savings, year 2000. 50% increase in battlefield range 	DSB, "More Capable Warfighting Through Reduced Fuel Burden", January 2001	\$300M
Totals			Savings: \$1.0 billion/year		\$7.3 – 9.9B

A. Military Applications – Summary of Recent Studies on Weapons Platforms

The military has the largest potential for savings in non-building applications due to its fuel-intensive activities in aircraft, ships and land-based supply, support and combat

missions. “The DOD testified in September 2006 that its energy use represents about 1.2% of total U.S. energy use... Of total DOD energy use, mobility fuels for aircrafts, ships and vehicles account for about 74%. Jet fuel (JP 8), also used for tanks, other ground vehicles and electrical generators, accounts for 58% of DOD’s consumption. Marine diesel fuel accounts for 13%.”⁸

The rapid rise in fuel costs has helped to focus the Defense Department’s efforts on energy efficiency to lower fuel demand and use in its operations. Fuel prices affect military modernization. Every \$10 increase in the price of a barrel of oil costs the military \$1.3 billion a year and unexpected increases generally come out of budgets for acquisitions.

Over the past seven years, numerous sources have examined the potential to retrofit and modernize mobile weapons platforms (air, sea and land-based) to increase fuel efficiency using known and available technology. Retrofits and modernization that produce substantial savings appear to be good potential candidates for using ESPCs to achieve energy-efficient capital investments.

1. Aircraft

Some of the most substantial and best documented fuel cost savings opportunities in military applications are in aircraft, both weapons platforms and transport planes. The Air Force represents more than 50 percent of the federal government’s total use of fuels, more than 60 percent of which is devoted to transport planes and bombers. A 2007 study commissioned by the Air Force from the National Academy of Sciences’ National Research Council (NRC) analyzed potential engine replacements or retrofits for a variety of large non-fighter aircraft, and found numerous opportunities that would save more than a hundred million gallons a year, improve range and reliability, and reduce environmental impacts and maintenance costs.⁹ When the total costs of acquiring and delivering fuel are accounted for, the study found that every major non-fighter aircraft operated by DOD could replace or significantly modify its engines with a payback of less than 20 years.

NRC presents an explanation of why efficiency advances in commercial jet engines present an opportunity for military aircraft. Commercial aircraft are flown as much as practically possible, in order to repay and earn profit on their investment cost. Fuel is the greatest operating cost for commercial aircraft, and improvements in fuel efficiency are adopted when cost-effective. These aircraft experience more than eight times as many flight hours annually than a typical military aircraft, which needs to be flown enough to

⁸ Ronald O’Rourke, Foreign Affairs, Defense, and Trade Division, Congressional Research Service, CRS Report for Congress, “*Navy Ship Propulsion Technologies: Options for Reducing Oil Use – Background for Congress*”, December 11, 2006.

⁹ “Improving the Efficiency of Engines for Large Nonfighter Aircraft”; Committee on Analysis of Air Force Engine Efficiency Improvement Options for Large Non-fighter Aircraft, National Research Council; 2007

maintain training, but otherwise kept in readiness. Military airframes therefore have much longer useful lives; because of this, some of the fleets' technology is, on average, behind the times. More fuel-efficient engines have been developed in, for example, the several decades since the TF33 engines on B-52s (and several other large aircraft) were first put in service.

The NRC study presents a “constrained cost-benefit analysis” of replacing or modifying engines for “each viable engine/airframe modification or re-engining candidate.” Costs of the new engines themselves and testing, design and modifications for airframe, controls, weapons systems or other changes that might be required are included; benefits assessed were fuel cost and maintenance savings. The NRC acknowledged but did not attempt to monetize additional benefits that would accrue: faster arrival to and longer “loiter time” in the battlespace, shorter runway requirements due to improved thrust, reductions in use of imported oil and air and noise pollution.¹⁰

The NRC study in 2007 used a base fuel price of \$2.14 per gallon. Payback periods within which savings will recoup costs were calculated based on 3 percent, 6 percent and 9 percent fuel cost inflation. Those costs and escalation rates, and therefore the savings estimates, were completely eclipsed just one year later. As of September, 2008, the International Air Transport Association (IATA) reported that their average jet fuel cost was \$3.08/gallon, and the rate of inflation as 33.5 percent from one year ago. Half a year later, the price was \$4.09/gallon, nearly double what it was when the NRC completed its analysis, and prices have fluctuated near three dollars per gallon since then.

¹⁰“Improving the Efficiency of Engines for Large Nonfighter Aircraft”, op. cit.

Figure 1: Sensitivity of Years to Recoup Investment to Total Burdened Fuel Cost¹¹

Candidate Aircraft/ Engine Configuration	Years to Recoup Investment with Total Burdened Fuel Cost of				
	\$2.50/Gal ^b	\$5/Gal ^b	\$10/Gal ^b	\$20/Gal ^b	\$40/Gal ^b
Re-engining					
C-130H/AE 2100 ^c	17.7	10.9	7.3	4.2	2.5
C-130H/PW150 ^c	19.5	11.7	7.9	4.8	3.1
B-1/F119/5.0	>60	55.7	24.4	12.9	7.8
E-3/CFM56-2B-1	22.2	15.7	10.5	7.2	5.2
E-3/JT8D-219	36.3	26.2	17.5	11.3	7.5
E-3/CFM56-7B22	16.5	11.6	8.0	5.7	4.0
E-8/CFM56-2B-1 ^d	—	—	—	—	—
E-8/JT8D-219 ^d	—	—	—	—	—
E-8/CFM56-7B22 ^d	—	—	—	—	—
KC-135D/E/CFM56-2B-1	45.1	28.6	17.6	11.0	7.4
KC-135D/E/JT8D-219	>60	48.9	27.8	16.3	10.0
KC-135D/E/CFM56-7B22	31.6	20.9	13.5	8.8	6.2
B-52/F117-PW-100 [4]	20.6	13.2	8.7	6.1	3.9
B-52/CF34-10A [8]	28.4	20.0	13.3	8.9	6.3
B-52/CFM56-5C2 [4]	16.1	11.2	7.8	5.6	3.6
C-5/CF6-80C2 (F103-GE-102) ^e	—	—	—	—	—
Engine modification					
KC-135 R/T/CFM56-2B-1 Mod	>60	>60	30.0	15.9	9.5
C-130H/T56-A427 Mod ^c	17.8	11.1	7.6	4.6	3.1
C-130H/T56-S3.5 Mod ^c	26.1	15.3	9.9	6.6	4.1
B-1/F101 Mod	8.0	6.9	5.4	4.3	4.1
KC-10/CF6-50 Mod	3.8	3.6	3.3	3.0	3.0

NOTE: The engine cost estimates presented are derived from correlations developed for historical military engines and may not reflect the current fair market prices of commercial engines considered in this study. Engine cost estimates vary widely, and the estimates presented may vary by as much as 100 percent from estimates developed by other independent sources such as the Avitas *BlueBook of Jet Engine Values 2007* or the IBA *Engine Value Book 2005*.

^aValues corrected after release of the January 31, 2007, prepublication version of the report.

^bShading indicates a recouping of investment costs in less than 20 years and thus a positive cash flow at the 20-year point.

^cThe fuel savings noted for the C-130 with new or modified engines are based on the aircraft being flown at the optimal altitude and airspeed for the selected engines and propellers. The flexibility exists in most C-130 missions for the aircraft to be operated at the best range or fuel consumption conditions. The other aircraft and engines considered in the study are operated at their prescribed mission conditions.

^dE-8 re-engining already in progress.

^eC-5 re-engining already in progress

The NRC study also tabulates the payback periods that would be required to recoup investment if the burdened cost of fuel is accounted for: i.e., the actual delivered costs of fuel to the battlespace where it is used, taking into account delivery logistics, aerial refueling, and security (see Figure 1). At a price of \$2.50/gallon – significantly lower than the present commercial cost of jet fuel– 7 of the 17 replacement/retrofit options analyzed pay for themselves within 20 years. At a burdened cost of fuel of \$20/gallon, every single one of the re-engining and modification options analyzed has a payback within 20 years.¹²

¹¹“Improving the Efficiency of Engines for Large Nonfighter Aircraft”, op. cit.

¹² Ibid.

In 2004, the DSB estimated the fully burdened cost of fuel at \$17.50/gallon in 1999 dollars.¹³ A 2006 Air Force analysis (before the fuel cost inflation of 2007-2008) stated that the cost of fuel for in-flight refueling was \$24.23 per gallon, for a fully burdened cost of \$26.37 per gallon¹⁴. The 2008 DSB report “More Fight – Less Fuel” cited delivered fuel costs in the range from a low of \$4 per gallon for ships on the open ocean to \$42 per gallon for in-flight refueling to several hundred dollars per gallon for combat forces and forward operating bases (FOBs)¹⁵. The implication is that if all the costs of delivering fuel to Air Force aircraft are accounted for, replacement or retrofit of virtually every engine system used in the non-fighter fleet could be cost-justified. The savings implied by these estimates generally assume a significant change to the infrastructure or to other elements of the burdened cost, which may be difficult. For example, fewer in-flight refuelings and less frequent maintenance needs will reduce variable costs such as fuel use by tanker aircraft and parts and consumables used in maintenance, but the full cost savings would not be realized unless there were reductions in the aircraft fleets, maintenance facilities and/or personnel and related infrastructure that is currently devoted to refueling. However, even if not all potential cost savings can be easily realized, the NRC study makes clear that there are a significant number of cost-effective retrofits available, even if only the direct cost of fuel and maintenance are claimed.

TF33 Engines and B-52s: Instructive examples

One engine system alone, the TF33 aircraft engine, found on KC-135E, E3 AWACS, E-8 JSTARS, and B-52H airframes, has been proposed by several sources in numerous studies as a candidate for replacement to yield fuel savings and improve range. In a 2002 DSB study, re-engining B-52s was estimated to yield as much as \$1 billion in savings, even when figuring the price of fuel at the then-current direct cost of \$1.20 per gallon.¹⁶ The cost a decade later has been sustained at a much higher level and as noted above, the total potential savings is the actual delivered costs of fuel to the battlespace where it is used – taking into account delivery logistics, aerial refueling, and security. Thus, that total is ten to fifteen times the purchase price of the fuel.

A summary of the DSB study on B-52H re-engining noted the following recommendations:

- B-52H re-engining represents low technical risk.
- B-52H re-engining provides greater operational flexibility and range, reduces fuel burn and tanker demand, and produces significant depot, field maintenance and manpower cost savings.

13 “Acquiring Combat Capability through Innovative Uses of Public Private Partnerships”; Buchanan, Cabell & McCrary, Naval Postgraduate School, 30 June 2006., citing Defense Science Board Task Force, B-52H Re-engining (Washington, DC, 2004)

14 “Improving the Efficiency of Engines for Large Nonfighter Aircraft”, op. cit., p. 15

15 “More Fight – Less Fuel” Defense Science Board Task Force on DoD Energy Strategy (Washington, DC, February 2008)

16 “Final Report of the Defense Science Board (DSB) Task Force on B-52 Re-Engining”, December 2002.

- B-52H re-engining is an excellent pilot program for expanding the use of ESPCs beyond fixed facilities and into mobile systems.¹⁷

The B-52 also represents one of the best arguments for ESPC as opposed to direct use of appropriated funds because the fundamental engine technology is several decades old, and there are over a decade of authoritative studies that document the savings available. One characteristic, noted in the 2002 DSB report and updated by the National Research Council, is particularly illustrative: the TF33 engine requires a complete removal from the aircraft and overhaul four to six times more often than do modern equivalent commercial aircraft engines, and re-engining would effectively eliminate this cost during the remaining life of the airframe. The cost of these overhauls, estimated at \$257,000 per aircraft in 1996, had escalated to \$1.25 million per engine in 2006.¹⁸ This constitutes yet another stream of costs that could be saved with re-engining. The NRC study, reviewing the evidence on all aircraft powered by the TF33, concludes that all applications of the engine should be removed from the inventory, noting this would allow an \$800 million maintenance inventory to be disposed of and more than 188 personnel and 82,000 square feet of support real estate to be redeployed for other Air Force needs.¹⁹

Financing and Implementation

Despite several analyses of the potential benefits over the past two decades, non-fighter aircraft have not been re-engined solely for fuel savings.²⁰ NRC attributes this principally to the challenges of justifying large initial investments in an era of constrained budgets and competition from other funding priorities, as well as to difficulties in exploiting long-payback savings opportunities within federal expenditure and procurement guidelines.²¹

NRC concludes their analysis with ten policy options, four to be implemented “right away”, four others to be “aggressively evaluated”, and two sale-leaseback options they acknowledge are outside federal procurement and financing practices. Among the “right away” options, NRC recommended the implementation of a “Fuel Savings Performance Contract Strategy”. They recommend this strategy as a viable response to the key challenges noted above to funding through capital appropriations, and note that “for specific capital investments programs, such as energy and utilities investment projects, Congress has managed to provide specific authorities that overcome the challenges and allow for alternative approaches to financing capital investments.”²²

The NRC report acknowledges and describes the existing building ESPC authority in 42 USC 8287, and notes that equipment replacements/retrofits that are life-cycle cost-effective are the very sort of capital investment for which ESPC has been so successfully applied in federal buildings. The NRC also states that it found no restriction to applying the use of an ESPC to aircraft propulsion systems.²³

17 “The Folly of Consequence-Free Budget Scoring”, PowerPoint presentation by Gerald Koenig, Hannon Armstrong.

18 “Improving the Efficiency of Engines for Large Nonfighter Aircraft”, op. cit., p. 40

19 Ibid., p. 41

20 Ibid., p. 106

21 Ibid.

22 Ibid, p. 111

23 “Improving the Efficiency of Engines for Large Nonfighter Aircraft”, op. cit., p. 112

Aircraft Wingtip Modifications

The Air Force's National Research Center commissioned an assessment by the National Academy of Sciences (NAS) to study the potential for wingtip modification to increase fuel efficiency on cargo, tanker and common airframes within the fleet. Based on fuel consumption the aircraft examined were the C-5, C-17, KC-10, KC-135, and C-130, all non-fighter aircraft with long mission time requirements.

A winglet, a common wingtip modification, is a retrofit that up-sweeps the wing to near vertical at the tip, and is a common sight on commercial aircraft. The winglet reduces aerodynamic drag and improves lift without significantly increasing overall wingspan. This results in a net aerodynamic performance improvement with benefits including reduced fuel usage, increased payload capability and improved take-off performance.²⁴

Based on recent studies, commercial experience with winglet retrofits on Boeing 737s indicate a 2.4 percent fuel savings for trips of 500 nautical miles (nmi) and 4 percent for trips of 2,000 nmi. Winglets are projected to save, on an annual basis, 130,000 gallons of fuel per aircraft for 737s and up to 300,000 gallons of fuel per aircraft on the 757.²⁵ Net fuel savings is affected by length of trip since savings occur during flight and not on the tarmac. The ratio of tarmac to flight time is greater for shorter trips.

Greater fuel efficiency results in multiple benefits. The aircraft can carry the same payload a greater distance, providing greater operating range. The aircraft can also carry a larger payload for the same distance and fuel. For commercial aircraft this benefit becomes meaningful for ranges beyond 2000 nmi.²⁶ Increasing payload range capability is valued in military missions. Carrying more payload the same distance could reduce the number of sorties to meet objectives.

Reduced drag from wingtip modifications reduces thrust necessary to achieve take-off. This can translate to increased climb rate which would allow the use of airfields with shorter runways, or those located at higher altitudes and in hotter climates. It also may improve combat performance in that the aircraft would have increased ability to achieve a steep climb on take-off to reduce vulnerability to surface-to-air threats.

Costs for a wingtip modification retrofit include non-recurring engineering for the specific airframe model, wingtip design, manufacturing and installation. Based on current retrofits for the commercial narrow-body aircrafts such as Boeing 737s, wingtip modifications cost from \$500,000 to \$1 million per aircraft. For wide-body airframes such as a Boeing 767, costs are between \$1 million and \$1.5 million.

24 "Assessment of Wingtip Modifications to Increase Fuel Efficiency of Air Force Aircraft" National Academy of Sciences, 2007

25 Ibid., p. 25

26 Ibid., p. 26

Based on net present value analysis, the 2007 NAS assessment prioritized five military aircraft on cumulative fleet benefit from wingtip modifications and determined that the KC-10 and KC-135(R/T) based on the DC-10 and Boeing 707 airframes, respectively, have the highest overall benefit. The assessment was based on multiple factors, including the expectation that “Some of these aircraft are expected to be in service until approximately 2040.”²⁷

The results shown in Tables 3 and 4 suggest that modifying the KC-135R/T and KC-10 fleets could substantially benefit the Air Force. These tables delineate results based on the parameters of fuel price and cost of modification. With jet fuel prices hovering around \$4.00/gal (their approximate level from 2008 to 2013), simple payback from a wingtip modification for a KC-135 was estimated to range from 3.9 to 12.9 years and, for a KC-10, from 3.6 to 12.1 years.

Table 3: Wingtip Modification Payback Period for a KC-135R/T Using 649,000 gal/yr²⁸

Estimated Cost of Modification (FY07 \$M)	Fuel Usage Reduction from Modification (%)	Fuel Saved (K gal/yr)	Fuel Cost Saved (FY07 \$K)	Payback Period (years)
Fuel at \$4.00/gal				
0.5	5	32	130	3.9
0.5	3	19	78	6.4
1.0	5	32	130	7.7
1.0	3	19	78	12.9

Table 4: Payback Period for a KC-10 Using 2.057 million gal/yr²⁹

Estimated Cost of Modification (FY07 \$M)	Fuel Usage Reduction from Modification (%)	Fuel Saved (K gal/yr)	Fuel Cost Saved (FY07 \$K)	Payback Period (years)
Fuel at \$4.00/gal				
1.5	5	103	412	3.6
1.5	3	62	248	6.0
3.0	5	103	412	7.3
3.0	3	62	248	12.1

²⁷ Ibid., p. 88

²⁸ Ibid., p. 65

²⁹ Ibid., p. 66

As with re-engining non-fighter aircraft, the Air Force National Research Council recommends developing implementation strategies to include innovative financing, such as specifically creating a line item in the defense budget, implementing an *energy saving performance contract* strategy, and competing airframe maintenance contracts that could be used to implement wingtip modifications.³⁰

2. Ships

According to the Naval Research Advisory Committee (NRAC) in a 2005 study, Navy ships account for eight percent of DOD's fuel consumption, or about 24,000 barrels of oil per day (BPD).

Reducing energy use in fossil-fueled ships can reduce costs and increase range, thereby improving fleet stationing capability by decreasing refueling frequency and increasing a ship's range away from refueling points. If efficiency measures are applied to enough ships, the resulting fleet range may allow for a reduction in the fuel-related infrastructure, such as oilers and storage facilities, and their associated costs.

Bulbous Bows

The bulbous bow is widely used on large commercial ships, where it can reduce fuel consumption by five percent at cruising speeds. The bow bulb represents a change in the shape and location of the ship's bow wave to reduce hydrodynamic drag. The Navy now features bulbous bows on aircraft carriers and on amphibious, auxiliary, and support ships. The Navy also has examined incorporating them into surface combatant ships (destroyers, cruisers and frigates). A Navy study by the David Taylor Model Basin (DTMB) estimated that the addition of a bulbous bow on an Arleigh Burke (DDG-51) class destroyer could reduce annual fuel use by 3.9 percent, or 2,400 barrels³¹. An earlier (1994) DTMB study estimated that 79 Navy cruisers and destroyers could be fitted with bow bulbs for less than \$30 million and yield a life-cycle fuel savings of \$250 million. Similarly, DOD stated in 2000 that fitting bow bulbs onto 50 Arleigh Burke class destroyers could save \$200 million in life-cycle fuel costs³². Based on commodity and labor cost increases over the past decade, the economic basis of performing this retrofit has improved markedly.

Hull and Propeller Coatings

The latest commercial marine hull coatings are based on silicone elastomer or fluoropolymer technologies that provide a smooth surface to which marine organisms cannot attach or adhere strongly. Propeller coating materials under consideration include

³⁰ Ibid., p. 11

³¹ Dominic S. Cusanelli, "Stern Flaps and Bow Bulbs for Existing Vessels, Reducing Shipboard Fuel Consumption and Emissions," December, 2000.

³² Ronald O'Rourke, Foreign Affairs, Defense, and Trade Division, Congressional Research Service, CRS Report for Congress, "*Navy Ship Propulsion Technologies: Options for Reducing Oil Use – Background for Congress*", December 11, 2006.

metal borides and nanomaterials-based metal oxide. Benefits range from reduced cavitation and erosion to anti-fouling and fuel efficiency. According to 2006 DOD testimony, applying special coatings to Navy ship propellers may reduce ship fuel use by four to five percent with possible maintenance savings resulting in a one-year payback. Coatings can reduce a propeller's friction and reduce corrosion, aiding in maintaining higher efficiency and reduced maintenance.³³ If applied to 200 ships, savings are estimated to be approximately \$142 million per year with total implementation costs expected to be approximately \$200,000 per ship or \$40 million in total.³⁴

Ship Hotel Loads

The DSB estimates that nearly one-third of the Navy's non-aviation fuel goes to "hotel loads," facilities such as pumps, fans, chillers, and lighting that make the ship habitable for its occupants. Hotel loads do not include shipboard operations such as propulsion, radars, weapons systems, and aircraft-launching catapults.

A study conducted for the Navy in 2001 by the Rocky Mountain Institute found that hotel energy loads could be substantially reduced on the Aegis cruiser, Princeton (CG-59). The Navy has 27 ships in this class. Key findings of the study:

- The Princeton uses approximately \$6 million worth of diesel fuel per year for gas turbines that are very similar to older commercial jet engines.
- \$2-3 million of fuel is used to produce 2.5 megawatts required for shipboard electrical loads. The remainder is used for 80,000 horsepower of propulsion.
- Retrofitting electric motors, pumps, fans, chillers, lights, and potable water systems could save 20 – 50 percent of the ship's electricity, cutting its fuel use by 10-25 percent.
- Since electricity is made from fuel mainly delivered by ship (oilers), it costs over \$0.27/kwh, which is more than six times the typical industrial tariff.
- Each ship board chiller could be improved to save its own capital cost (\$120,000) every eight months.
- Re-configuring the fire pumps to operate automatically when needed instead of constantly circulating pressurized seawater with two 125 hp pumps could save over \$200,000/year.
- The Princeton's total electricity savings potential could reduce energy costs (in the form of fuel) by nearly \$1 million a year. Reducing fuel use for power needs increases overall operating range.³⁵

With over 300 ships, the Navy's potential to reduce hotel loads is significant. Increasing the efficiency of a ship's electricity use also directly benefits war-fighting capability by enabling them to go farther without refueling. Since the current cost of fuel has increased by over three-fold since the time of this DSB study, savings and overall return-on-

33Joint Statement of Honorable John J. Young, Jr., Director, Defense Research and Engineering, and Mr. Philip W. Grone, Deputy Under Secretary of Defense (Installations and Environment), Op. cit.

34Al Shaffer, Director, Plans and Programs, Op. cit.

35Amory B. Lovins, "All Energy Experts on Deck!" available online at <https://old.rmi.org/sitepages/pid955.php>

investment has increased dramatically for the Navy. Many of the improvements to shipboard hotel loads are similar to those made in buildings via traditional ESPCs.

Higher Efficiency Gas Turbines

Gas turbines with greater efficiencies than simple cycle gas turbines currently used in Navy surface ships could significantly reduce Navy ship fuel use. An example is the WR-21, an inter-cooled recuperated (ICR) gas turbine engine that was a joint development effort between the US, UK and French governments. This 25 MW engine offers a 27 percent fuel savings over currently used simple cycle gas turbine marine engines. Other benefits include lower manpower demands, increased mission capability, enhanced reliability, a reduced signature, decreased maintenance, and reduced life-cycle costs. It is projected that this engine in a new destroyer would save about \$1.5 million per year in fuel and operating costs, which could pay back the premium on the original purchase in two to six years.

Diesel Engine/Generator Improvements

The Navy's Development, Test and Evaluation program includes goals to improve fuel efficiency, primarily in legacy ships. Funding for efficiency improvements decreased by over 75% during the 1990s as the cost of fuel decreased. Ship-based power plants consume over 37 million gallons per year or 18% of total fleet fuel use. The Navy fleet has 2,428 diesel power plants of which 14% are medium-speed engines and 86% are high-speed engines. The following efficiency measures have been identified:

- Retrofit electronic fuel injection – fuel reduction up to 5% saving 71,000 gal/yr. per /ship along with \$250,000/yr. per ship in maintenance.
- Low load operations management – fuel reduction up to 14%, saving 125,000 gal/yr. per ship in fuel and \$305,000 in maintenance.³⁶

Navy Secretary Mabus's vision for a "Great Green Fleet", part of a sweeping energy efficiency and alternative energy utilization plan throughout the Navy, include many of these vessel efficiency improvements:

"At least 220 of today's Navy's 286 ships will still be in service in 2020 as part of the Great Green Fleet." In order to meet alternative energy standards, they will have to be retrofitted with new power-generating equipment and hull alterations. Upgrades to hull design—reducing wave resistance, altering water flow, and cutting drag—can be costly, but they can increase fuel efficiency tremendously, saving millions of dollars. Three of these technologies have been retrofitted to various surface ships during dry-dock availabilities: bulbous bows, stern flaps, and propeller and hull coatings.³⁷

³⁶ "More Capable Warfighting Through Reduced Fuel Burden" Op. cit.

³⁷ "The Great Green Fleet" Lieutenant Alaina M. Chambers, U.S. Navy, and Steve A. Yetiv, U. S. Naval War College Summer Review 2011.

As of this writing, it is not known what financing methods were employed for these retrofits.

3. Land Platforms/Vehicles

Retrofits for Legacy Systems in the Abrams M1 Tank

The Rand Corporation's "Fuel Efficient Army After Next" studies (1998) identified achievable fuel efficiency improvements of 35 percent achievable by modifying existing vehicle subsystems for the Abrams M1A2/A1 tank. It also estimated that retrofitting with completely new subsystems could improve fuel efficiency by 60 to 80 percent.

Re-engining the 1960s vintage AGT 1500 turbine engine in the Abrams tank would yield a host of benefits. A number of manufacturers produce engines that could replace the existing ones. These commercially available units would produce:

- four to five times improvement in mean time between failures (MTBF)
- 15 to 20% improvement in mobility
- 35% reduction in fuel consumption
- 42% fewer parts
- 40% reduction in cost of ownership over 30 years³⁸.

The Army embarked on the LV100 engine development program for the Abrams and awarded the contract to GE and Honeywell. The final iteration LV100-5 was going to be the common engine with the Crusader self-propelled howitzer, but the program was shelved with the cancellation of the Crusader program.

Auxiliary Power Unit for Abrams M1A2 Tank

The Under Armor Auxiliary Power Unit (UAAPU) is a small auxiliary turbine engine that is built into the M1A2 tank as a modification. It may be used to power the tank's electrical, climate, and hydraulic systems without operating the main engine. Since many hours of tank operations are stationary including combat "silent watch" mode, operation and support savings accrue from the reduced main engine operating hours. Using the UAAPU in "silent watch" mode also increases survivability by reducing audible and heat signals.

The UAAPU uses fuel at four gallons per hour versus the main engine at 12 gallons per hour. Refitting 996 M1A2 tanks was projected to cost \$322 million. The fleet consumes an average of 13.7 million gallons of fuel without APUs, and 4.6 million with the APUs. Using an estimate of fully burdened peacetime fuel cost of \$39/gallon³⁹(for M1A2s, at a DLA-Energy JP8 fuel price of \$3.04/gallon), the payback period would be about one year.

³⁸"More Capable Warfighting Through Reduced Fuel Burden" Op. cit.

³⁹ Ibid.

Engine, Transmission and Differential Coatings

The Army operates and maintains the largest trucking fleets in the U.S. Specialized coatings on engines, transmissions and drive trains for the Army's truck fleet potentially could save significant costs from increased overall performance, reduced fuel consumption and maintenance.

It is anticipated that applying top candidate coatings such as metal borides or nano-materials-based metal oxide to a truck's drive-train would cost approximately \$400 per vehicle. Estimates of fuel savings are as high as 10% with 3% better engine performance and 10% better transmission and differential performance. Assuming 37% of the light tactical vehicles (LTVs) and medium tactical vehicles (MTVs) received coatings, and given a JP8 fully burdened cost \$5.62/gallon (for these vehicles), total savings would be about \$500/vehicle, resulting in payback period of less than one year.⁴⁰

4. Tactical / Mobile Power Generation

Mobile power generation is critical to logistic support and battlefield operations. Costs to supply power to a war zone include fuel, maintenance, transportation, and support personnel. Tactical or mobile power costs approximately \$3.00/kWh compared with typical gen-set power at \$0.40/kWh and grid power at \$0.085/kWh.⁴¹ Fuel and support personnel comprise 45% and 35% of the total costs, respectively. The highest potential for savings is in fuel efficiency and maintenance. Opportunities to improve efficiency come from alternative fuels, improved diesel engine technology, and alternative generation technologies including renewable technologies and high density energy storage.

Though no direct savings numbers have been estimated in previous studies, the need for quiet, highly efficient, and highly mobile power systems will likely increase. Future "digital" soldiers will be using three to ten times more power than today's soldiers. In some field operations, there may also be end-use efficiency measures that add to these savings potentials. An example may be recent initiatives to insulate tents used for field operations in Iraq and Afghanistan, which not only reduced power demands for air conditioning, but also improved occupant comfort and productivity.

B. Federal Civilian Agency Applications

Potential applications of ESPC for non-buildings uses among civilian federal agencies are less common and substantial than among mobile weapons platforms. In part, this is

⁴⁰Al Shaffer, Director, Plans and Programs – Office of Director, Defense Research and Engineering and Joe Illar, Office of Program Analysis and Evaluation, "*DoD Cost of Energy and Options for the Future*", presentation October 9, 2007.

⁴¹ "Estimating Cost of Project Electric Power onto a Battlefield", Presentation, Dr. Michael E. Canes, Logistics Management Institute, April 8, 2004

attributable to use-cycle characteristics of weapons platforms. Unlike civilian vehicles, these platforms are intended for readiness in time of conflict rather than routine and steady use, and therefore may have extended useful lives within which considerable advances in the fuel efficiency of propulsion technologies may occur. In addition, the number of available studies of weapons systems' efficiency potential reflects the growing awareness within DOD and the DSB of the impact of accelerating energy costs on the Armed Services' war-fighting capabilities. Nonetheless, there are notable exceptions within civilian agencies where non-buildings savings could be substantial.

One example is the potential for efficiency improvements in the power generation capability of federal hydroelectric facilities. The majority of federal hydroelectric dams are operated by the Army Corps of Engineers (USACE) and the Department of Interior's (DOI) Bureau of Reclamation (BurRec). USACE and BurRec control 78% of all federal dams, and 91% of total federal hydroelectric dam capacity. The electricity produced by these dams is marketed by the Department of Energy's (DOE) Power Marketing Administrations (PMAs). DOE's PMAs collect revenues and deliver electrical power to municipal utilities, rural electric cooperatives and electrical retail distributors such as the Tennessee Valley Authority (TVA). Most federally owned and operated hydroelectric facilities are operating well beyond their design life of 35 years. The average age is nearly 50 years.

Hydroelectric turbine and generator technology has advanced to provide 40% more power at the same water flow rate than its predecessor technologies. Moreover, replacing older turbines with current technology yields the additional benefits of reducing or eliminating turbine maintenance or repair cost, and increasing dissolved oxygen levels from turbine discharge. Low dissolved oxygen in dam discharge requires reductions or even shut-downs in power generation due to the adverse environmental impacts downstream of dam facilities. Perhaps the best known examples are seasonal cutbacks or shutdowns of hydroelectric operations on streams with spawning migrations of fish such as salmon or steelhead. New aerating turbine runners can substantially increase the dissolved oxygen levels, mitigating downstream adverse impacts on fish habitat, and preventing power plant shutdown.

USACE hydroelectric facilities, the largest source of hydroelectric power in the U.S., have a high backlog of turbine replacement or repair projects, but do not have adequate Federal appropriations available to implement those upgrades, even though they could pay for themselves in savings within ten years. Likewise, the BurRec is the nation's second largest producer of hydroelectric power: 42 billion kilowatt-hours of electricity annually, and the largest water wholesaler in the U.S.⁴² An NRC study of BurRec infrastructure management suggests that it is experiencing similar backlog and lack of Federal funding availability:

⁴²Managing Construction and Infrastructure in the 21st Century Bureau of Reclamation, National Research Council, 2006, p. 18

The O&M burden for an aging [BurRec] infrastructure will increase, and the financial resources available to Reclamation, its customers, and contractors may not be able to keep up with the increased demand. Some water customers already find full payment of O&M activities difficult, and major repairs and modernization needs, if included in the O&M budget, impose an even greater financial burden that cannot be met under the current repayment requirements.⁴³

In Section 1834, Title XVIII of EPACT 2005, Congress requested an assessment of the potential for increasing power production at federally owned hydro facilities. This resulted in a 2007 study entitled “Potential Hydroelectric Development at Existing Federal Facilities.” The study’s assessment included both physical and economic viability, and found 64 BurRec and Army Corps sites with potential for new generating units totaling 1,230 MW of estimated additional capacity. More relevant to this study, the NRC estimated an additional 1,283 MW of capacity could be gained through rehabilitating existing power generating units.⁴⁴ Assuming an average capacity factors (CF) for federal hydro dams of 35%, the National Renewable Energy Laboratory has conservatively calculated that this increased capacity of 1,283MW at 35% CF would result in increased annual electrical power production of roughly 3,900 GWh/year.

ESPCs for Federal Dam Rehabilitation – Increased Power Generation Potential

An ESPC project for federal dam rehabilitation would entail ESCO installation of new turbines, replacement of critical generator components, and related control system upgrades. In 2002, an ESCO under DOE and USACE ESPC contracting authority conducted a preliminary project analysis of re-powering a Southeastern USACE dam. Such preliminary proposals are treated as proprietary under ESPC contract authority; however, DOE obtained permission to use illustrative numbers without attribution. The dam, with a nameplate rating of 135 MW, was projected to require an investment of approximately \$56 million for re-powering, which would generate annual energy cost benefits of \$1.5 million and \$4.3 million in increased energy production and electric capacity payments, respectively, and \$1 million in reduced repair costs. The resulting simple payback is eight years. This is within the ESPC contract authority limit of a 25-year contract duration, assuming that there would be a three year period from ESPC contract award until full rehabilitation of generating capability, and further assuming that ESPC financing requires less than double the simple payback duration for complete amortization of a financed retrofit.

1. Fleets/Trucks

Government fleet applications for fuel conversion and related cost savings from reduced fossil fuel sources likely do not constitute significant potential for use of ESPCs. The engine, transmission and differential coatings retrofits discussed for military tactical and transport vehicles above are not expected to apply to civilian fleets, as these vehicles are not generally exposed to harsh driving environments. Currently, the civilian fleet transition to alternative fuels does not reveal enough cost savings to warrant use of ESPC.

⁴³ Ibid, p. 9 and 101

⁴⁴ Potential Hydroelectric Development at Existing Federal Facilities: For Section 1834 of the Energy Policy Act of 2005”; 2006, US Dept. of the Interior, US Dept. of the Army, US Dept. of Energy.

The current focus includes the acquisition of alternatively fueled vehicles, weighing the cost of alternative fuels (which may become more cost-effective in the future if fossil fuel prices continue to climb), and construction of alternative fuel infrastructure. In the future the environmental benefits of fleet transition to alternative fuels may be monetized through carbon savings, emissions reduction credits or other fungible cash streams. If these policies or regulations occur, then it may be possible to use that revenue stream as a source of repayment for ESPC financing of vehicle conversion to alternative fuels.

One approach that may show promise in the future may be the increased use of plug-in hybrids for civilian fleets. In this application, if the replacement cost of conventional gasoline fueled vehicles with plug-in hybrids is removed from the ESPC transaction there may be potential for adequate energy cost savings to implement ESPC for alternative fuel (electrical) infrastructure. EPACT 2005, EO 13423, EO 13514 and current administration directives all include fleet conversion requirements to alternatively fueled vehicles.

If vehicle replacement is prohibited from consideration for performance-based contracting, ESPC would be limited to the installation of electrical plug-in infrastructure, which could include PV powered car ports, where the replacement of gasoline or diesel fuel by electricity costs less per vehicle mile. If the alternatively fueled vehicle infrastructure is bundled with building energy efficiency, water conservation, and renewable energy systems, there may be a small niche of cost-effective applications. This is realistically a mid-term (10- to 20-year) strategy, as the current cost of hybrid plug-in vehicles is approximately \$30,000 to \$45,000, until volume manufacturing takes hold to result in cost-competitive government fleet conversions.

2. Ships

The U.S. Coast Guard (USCG), within the Department of Homeland Security, is the primary source of civilian ship fleets that could benefit from propulsion system retrofits (e.g., propeller and shaft coatings) as discussed above for naval vessels.

Further investigation of the USCG fleet is required at this time to inventory classes of vessels that have not undergone Fleet Renovation and Modernization Programs, such as the 378 foot High Endurance Cutters, where the entire 12-vessel class, commissioned in 1967, was renovated between 1980 and 1992. This also highlights the need to identify vessel classes still in high use that lack funding for renovation. The current USCG fleet comprises 218 Cutters (classified as 65-420 feet) and 747 Boats (classified as 25 to 47 feet).

3. Aircraft

The two largest civilian agencies with aircraft are the USCG and NASA. It is assumed that USCG and NASA aircraft could benefit from engine replacement and wing tip modifications as discussed above for military aircrafts.

USCG

Similar to the exploration of USCG vessel inventory, further investigation is required to identify USCG aircraft needing engine replacement or other efficiency improvements. The Coast Guard currently has 211 aircraft serving various missions from search and rescue, law enforcement, environmental response, and air interdiction. A large segment of the USCG fixed wing inventory is turbo-prop aircraft. Due to an increased USCG security mission, there are several aircraft acquisitions in progress or under development. Further investigation is necessary to identify older aircraft classes still planned for long term use that could benefit from propulsion system improvements.

NASA

Currently there are over 20 classes of fixed wing aircraft ranging from small four-seat prop aircraft, the workhorse P-3 four-engine turbo-props, T-38 training aircraft, to the large scale B-377 Guppy and 747 jets.

These classes of aircraft require further investigation to determine the number of planes likely to remain in service over the next 20 years for opportunities for potential retrofits (e.g., engine replacements).

Prominent civilian applications of mobile power include remote area research such as conducted by the National Science Foundation; remote stations for surveying and other observational work as required, for example, by the Department of the Interior's National Park Service; for remote communications stations, as operated by NOAA, FAA and other organizations; and general facility upgrades such as lighting or emergency phones where a simple stand-alone power system may be less expensive than connecting to the grid. No data quantifying the net potential for these applications have been identified.

4. Water Transport/Irrigation

The federal government owns vast water installations, mostly associated with irrigation and dams, including hydroelectric facilities. Responsibility for water projects lies primarily in the Bureau of Reclamation and Army Corp of Engineers. Most energy-usage falls within the hydroelectric facilities and any ESPC application would likely be part of a hydroelectric re-powering initiative discussed earlier. Most of the federally owned water transport projects are dams and associated gravity-fed systems via rivers. The water is ultimately delivered to state, regional, or local water agencies, where most of the energy-intensive pumping, transport and treatment takes place. It is not clear whether or not federal water transport or irrigation facilities present opportunities for ESPCs beyond hydroelectric plants. Repeated contacts with both agencies in the conduct of this study did not yield evidence of specific potential projects, but further examination

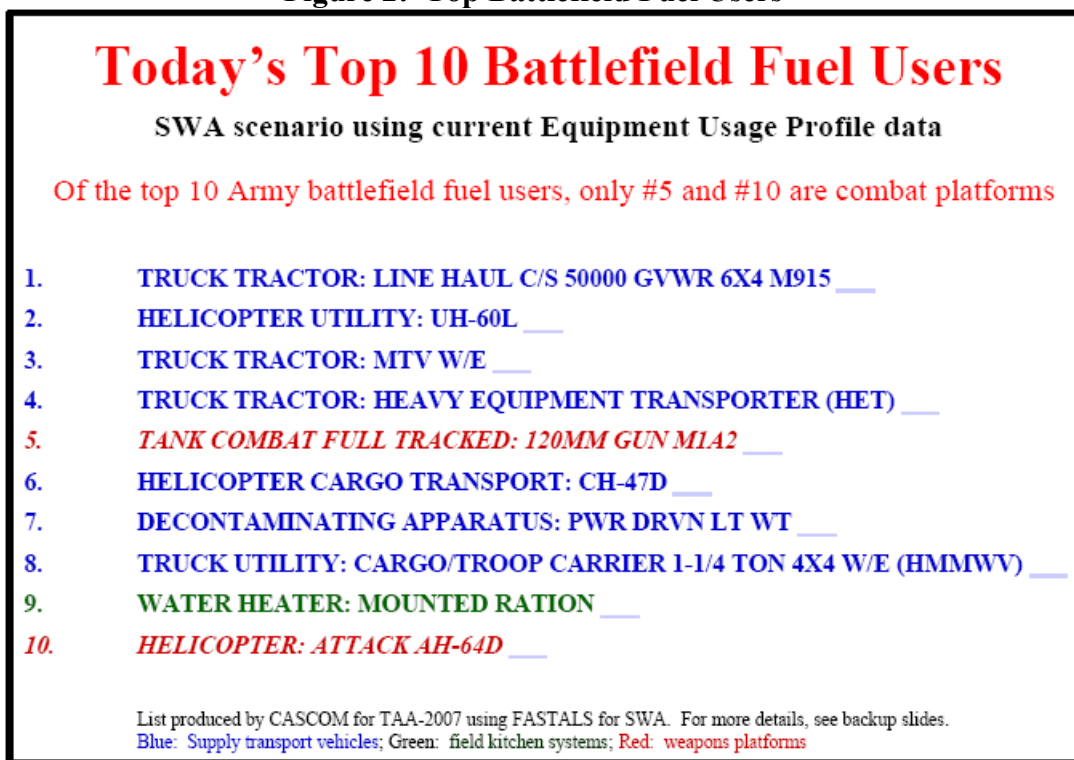
is warranted to explore potential benefits of using ESPCs for energy savings improvements to these facilities.

C. Secondary and Environmental Savings

1. Secondary Savings Opportunities

Significant secondary cost savings may be associated with the military and civilian mobility applications discussed in the preceding sections. These are due to indirect decreases in energy, personnel, materiel, and operations.

Figure 2: Top Battlefield Fuel Users⁴⁵



Indirect energy use may arise from logistical support associated with the primary users addressed in the preceding sections, particularly in the military context. For example, when the Army deploys into a theatre of operations, over 70 percent of the cargo weight transported is fuel. Of the top ten Army battlefield fuel users, only two, the M1A2 tank and the Apache Helicopter (Figure 2), are combat platforms. The rest are supply transport and one mobile kitchen system. Each battle tank is trailed by several large 5,000-gallon tankers. An armored division uses 20 to 40 times as many tons of fuel as it does

⁴⁵“More Capable Warfighting Through Reduced Fuel Burden” Op. cit.

munitions. Fifty-five percent of the fuel the Army takes to the battlefield does not go to front-line combat units; it is consumed by the logistics tail and its protection. The Army, for example, used \$200 million in fuel in 2000 and paid \$3.2 billion a year to maintain 20,000 active and 40,000 reserve personnel to move that fuel. Similar examples may be found throughout the military services, including for refueling of ships and aircraft in mission.

In addition to savings from reduced indirect energy use, there may also be cost savings from reducing required personnel (e.g., from the estimated 60,000 total active duty and reserve Army personnel cited above) or permitting shorter or less frequent personnel deployments.

Materiel costs may also be reduced by measures that decrease maintenance requirements and increase materiel lifetime, delaying costly replacements. For example, the ship propeller coatings noted above, in addition to decreasing ship fuel use, can reduce propeller friction and reduce corrosion.

Finally, there may be operational implications that directly affect the ability to perform certain military or non-military missions. For example, increased range for any form of mobility can permit missions that are longer in duration or further in distance. This may result in associated logistics support costs being reduced.

2. Environmental Savings Opportunities

In addition to primary and secondary cost savings opportunities, the more efficient use of fuel may translate to significant emissions reductions, including those contributing to pollution of the local environment and climate change. Environmental savings are more difficult to estimate. However, as more certainty is developed in assigning economic values to emissions, such savings could apply to ESPCs.

There are examples of ESPC building applications that resulted in financial benefits for air pollution reductions. Under an ESPC for a VA Hospital in San Diego, a new cogeneration plant was installed replacing an old cogeneration system that significantly reduced NOx emissions. As part of the ESPC project the NOx emission reduction credits were sold for nearly \$4 million dollars (nearly 30 percent of the capital cost of the new cogeneration system).

IV. Feasibility of Extending the Use of Energy Savings Performance Contracts to Non-Building Applications

The key element of ESPCs that differs from conventional government contracting is that they are paid from contractually guaranteed future savings, and therefore incorporate a debt instrument that capitalizes the future savings stream. It is necessary to establish a baseline of current and projected future energy and operating costs from which future

savings will be calculated, to establish the terms of the guarantee of those savings, and to establish methods through which savings will be measured and verified to confirm that the terms of the guarantee are being met.

These contract elements and the procedures through which they are implemented are very well established in the ESPC industry for buildings. Federal practices for the ESPC authority of 42 USC 8287 are highly developed and “routinized,” with extensive guidelines based on federal procurement law and more than a decade of experience. ESPC for non-buildings opportunities would share the vast bulk of these practices, but there are salient areas of potential differences in non-building applications that should be addressed, – some of which could make ESPC actually easier to implement, and others that might present challenges. Just as each individual building ESPC task order must result from careful negotiation of terms and responsibilities for the unique circumstances of each project, the exact details of each potential application of non-buildings ESPC will have to be worked out in advance based on the specific facts of that application. However, the following overview of potential challenges suggests that, while the same care must be exercised as is done with every prudent government acquisition, it appears that there are no insuperable obstacles to using ESPC to capture the energy and cost savings potential of non-buildings applications.

A. Measurement & Verification (M&V)

1. Performance M&V

The most crucial element of measurement and verification of savings in a performance contract is acquiring reliable data with which to establish performance baselines, and with which to measure savings after the installation of performance improvement measures. While the full range of potential non-buildings applications obviously represents tremendous variety, for many of the largest known and best studied non-buildings applications – the engine systems in military aircraft, vessels and ground-based weapons platforms -- this particular aspect of M&V is quite possibly easier than is the case for typical buildings ESPCs.

Ongoing measurement of energy use in buildings is often not highly sophisticated. While some modernized facilities have energy management control systems that manage and monitor energy consumption in important subcomponents of building systems, many do not. Most have one or two utility meters, the consumption data from which may or may not be monitored and retained by the building staff. Many large federal building complexes, such as military bases, have a small handful of meters for scores of buildings. These circumstances are changing in the federal sector due to recent statutory mandates for increased metering, but the fact remains that establishing building energy use baselines for performance contracts is a highly specialized procedure, often involving acquisition of raw data from servicing utilities, spot-metering of building subsystems through the project design phase, or entering what data are available into a model of building energy use that is then agreed upon by ESCO and client as the baseline for pre-retrofit energy consumption.

By contrast, the refueling needs of weapons platform mobility systems is a critical component of war-fighting readiness. Moreover, their reliability is so critical (consequences of aircraft engine failure are more serious than chillers going down), that the typical military weapons platform engine's performance is monitored, recorded and analyzed to a far greater extent than are building components.

It is beyond the scope of this study to confirm specific on-board engine diagnostics systems on every weapons platform that demonstrates potential for fuel and maintenance savings. However, modern weapons platforms increasingly have diagnostic and monitoring capabilities that far exceed that of most buildings, and should more readily support M&V of an ESPC. A few examples include:

- The B-52 was selected for an Air Force side-by-side test of Fischer-Tropsch synthetic fuel with JP-8 because of its fuel management system, which allowed isolation of fuel tanks and monitoring of consumption.⁴⁶
- The F-22 Raptor's engine systems have "advanced diagnostics that can immediately discover operational problems and identify them by part number."⁴⁷
- The Abrams Battle Tank, under the new Total InteGrated Engine Revitalization (TIGER) program, will have on-board monitoring capability for engine performance and fault detection that can be remotely monitored.⁴⁸
- Navy vessels have reported fuel consumption into the Navy Energy Usage Reporting Systems (NEURS) for several years, which is in turn linked to the Navy's Incentivized Energy Conservation (i-ENCON) program, a "best practices" effort.⁴⁹

In every ESPC, a necessary first step to creating a performance baseline and M&V plan is to specifically identify performance data availability and ongoing monitoring capacities. Every indication is that these prerequisites will be comparatively easy to meet for mobile weapons platforms. The DSB, in recommending that DOD investigate ESPCs as a possible mechanism for re-engining, noted that the extensive commercial experience with engine modernization provides ample benchmarking capability for M&V. Commercial history of modern high bypass fan engines provides a sound basis for calculating fuel and maintenance costs and for devising M&V plans.⁵⁰

While instrumentation and recordkeeping may be superior for a typical weapons platform, this may be offset by the challenges presented by operating schedules and characteristics. Agencies and ESCOs would need to develop baselines thoughtfully and carefully for these applications. Baseline and operational energy costs of combat systems (e.g., weapons and mobility platforms), which constrain where, when, and how ESPCs

⁴⁶AF press release 3/31/2008

⁴⁷ Avionics Magazine, F-22 Special Report, p. 4

⁴⁸Defense Industry Daily, June 4, 2008

⁴⁹Defense Industry Daily, July 15, 2008

⁵⁰Defense Science Board, 2002, op. cit., p.39

can be applied, may be challenging to establish. Besides the unpredictable effect of combat conditions that cause equipment and system failure or loss, many combat systems are used at highly variable rates, ranging from storage mode to full-time deployment. Moreover, a major driver of energy costs lies not in the direct point of fuel consumption, but in the indirect costs of delivering the fuel to where it is needed, the logistics attendant to that supply chain, and the mission tactics associated with a given vehicle's range.⁵¹ Characterizing "average" energy use profiles for these applications would require careful construction of "most-likely" projections by military agency personnel, and careful negotiating between agencies and ESCOs. Likewise, the development of realistic strategies for quantifying energy savings would place a burden on agencies that is greater than that for buildings, where the fully burdened costs of energy used can be simply metered and don't have to be reconstructed through multiple accounts and operational organizations.

2. Maintenance, Labor and Material M&V

Another major element of secondary cost savings are reductions in maintenance labor and material required as a result of energy efficiency retrofits. The agency and ESCO need to determine the current cost of personnel and material required prior to retrofits to establish this element of the savings. As is the established precedent in the federal buildings ESPC practice, labor costs savings must be real – reflecting actual reductions in maintenance personnel or contracts – rather than reassignment of personnel or contractors to other duties. Material cost savings can be estimated based on lifetime extensions for a particular piece of equipment, and also from reductions in frequency of maintenance operations.

Cost benefits of improvements to operational capabilities may be addressed using established methods, such as modeling of example applications or interviews with experts. All of these baseline derivation techniques are well established in the buildings ESPC practice, and can be replicated for mobile platforms.

B. Guaranteed Savings

1. Risk/Responsibility

The most common risk taken by the federal government under an ESPC is the utilization rate of an asset.⁵² The equivalent in a building ESPC is occupancy and hours of operation, which may change due to unforeseen circumstances, the most dramatic of which is the varying use of military assets with the vicissitudes of war. These are routinely dealt with in building ESPC by establishing an occupancy schedule based on

⁵¹Paul Dimotakis, Nathan Lewis, Robert Grober, et al., "*Reducing DoD Fossil-Fuel Dependence*", JASON for the Director of Defense, Research & Engineering. September, 2006

⁵²Buchanan, op. cit., p.24

historical data, an agency's long term site plans, and the agency's best judgment. Similarly, the usage of non-building assets can be reasonably projected, and provisions be made within ESPCs Risk/Responsibility Matrix if circumstances change.

The most dramatic change would be the case where a mobile weapons platform was destroyed by enemy action. This contingency was addressed in the two Naval Postgraduate School analyses of using ESPC for mobile assets, per the citations below:

"In its 15-year experience, Federal ESPC contracts have a significantly better record of success than other Federal contracts. There are no "Terminations for Default" on record and the few "Terminations for Convenience" cases have been most frequently precipitated by agencies using end-of-year excess funds to "buying out" well-performing ESPCs.

There have been a handful of "Terminations for Convenience" cases where the underlying asset was lost, such as a General Services Administration building located near the World Trade Center that was destroyed on September 11, 2001. This demonstrates an example of how an ESPC may be used for upgrading combat aircraft that could be lost to enemy fire or accident.⁵³

The experience of the GSA building adjacent to the World Trade Center is relevant. The government continued making payments for about six months and then terminated the contract for convenience, paying a lump-sum amount to the contractor in accordance with a termination liability schedule in the original contract.⁵⁴

There have also been cases of termination for convenience where buildings have been closed due to Base Realignment and Closure (BRAC). Again, these are dealt with through the contract clauses that are standard in every ESPC.

Additionally, one risk reduction strategy that is not readily feasible under typical buildings ESPCs could potentially be employed for war-fighting mobile assets: an agreed upon projection for anticipated survival rates could be built into the projection of guaranteed savings.

C. Applications Not Feasible Under Existing Legislation

Each of these non-buildings applications discussed in the study (military vessels, aircraft, and tactical and civilian vehicle fleets) cannot utilize the current ESPC statutory authority (42 U.S.C. § 8287), which is currently applicable only to existing Federal buildings and facilities.

⁵³ Ibid., p.27

⁵⁴ Miguel & Summers, "Using Public –Private Partnerships and Energy Savings to Fund DoD Mobile Assets", September, 2006

42 U.S.C. § 8287b states that the source of funds to pay for ESPC services provided by an ESCO is limited to appropriations made available for facility utility and related O&M expenses. Although the energy related O&M expenses could be construed to apply to mobility applications, the statute's language does not permit ESPC payments to be made from fuel cost savings for mobile applications.

Implementation Challenges

Long term payback

Payments to an ESCO for debt service and performance period services are predicated on an agency maintaining levels of energy funding that would occur absent the energy efficiency improvements. Therefore, the federal agency using the ESPC needs to maintain the current budgeted levels of funding in future fiscal years.

Funding Transfers

The full potential value of an ESPC for mobile systems may be realized across multiple entities and multiple budgets within an agency. This is sometimes true within building ESPCs, and has been dealt with effectively many times. The value of fully burdened fuel cost, for example, comprises fuel purchase, delivery to transportation assets (fuel trucks or refueling aircraft), transportation, and delivery to aircraft or ground-based equipment. If the burdened cost of fuel is used as the basis of ESPC payment, shorter paybacks can be expected. Whether the fully burdened fuel cost savings could actually be applied to mobile ESPC payments may be an organizational and accounting challenge. It can be assumed that, within a given civilian agency or DOD service there may be multiple organizational units responsible for funding fuel purchase, delivery, transport, security or other elements of fully burdened delivered fuel cost.

To apply these multiple cost streams to ESPC payments, each organizational unit may need to transfer its share of energy or secondary cost savings to the contracting office that performs contract administration and approves ESCO payments, or some higher organizational level may need to assume responsibility for payment (which is the solution most often applied in Buildings ESPCs). A key action needed early in a mobile source's ESPC project development would be identification of agency stakeholders that benefit from resulting energy and secondary cost savings. It is possible that fiscal policy changes may be required to allow transfer of budgeted appropriations from one organizational unit to the unit administering the ESPC contract.

V. Findings

The findings of this study indicate that significant potential exists in non-building applications to save energy and costs. This potential could save budget dollars, reduce reliance on fossil fuels, increase energy independence and security, and reduce greenhouse gas emissions. The Federal government has almost two decades of experience applying ESPCs to Federal buildings. Currently, Federal ESPCs are limited by statute to buildings. This study indicates that ESPC could potentially be an effective contracting and financing method for non-building applications.

If non-building ESPCs are pursued, amending the existing authorization (42 U.S.C. § 8287) to accommodate non-building applications would be required. Suggested revisions are provided below.

Changes to ESPC Legislation to Accommodate Non-Building Applications

1. Amendment to Cover Agency Payments from Reduced Fuel Use

Revise 42 U.S.C. § 8287(a)(2)(B) to add “or fuel supply, delivery, and transport providers” after “to both utilities”; and “or fuel supply, delivery and transport” after “paid for utilities.” This recommended amendment would result in § 8287(a)(2)(B) reading: “Aggregate annual payments by an agency to utilities, *fuel supply, delivery, and transport providers* and energy savings performance contractors, under an energy savings performance contract, may not exceed the amount that the agency would have paid for utilities *or fuel supply, delivery and transport* without an energy savings performance contract (as estimated through the procedures developed pursuant to this section) during contract years.”

2. New Section Authorizing ESPC for Non-Building (Mobility) Applications

Add after 42 U.S.C. § 8287(a)(2)(G): “(H) A Federal agency may enter into an energy savings performance contract under this title for the purpose of reducing fuel use, delivery and transport costs for non-building applications. Secondary savings shall also be considered as a source of cost savings (and payments) for non-building applications.”

3. Add Definitions of “Non-building Applications or Mobility Assets” and “Secondary Savings”

Amend 42 U.S.C. § 8287c by adding subsections (5) and (6) to include the following definitions related to non-building applications:

- (5) The terms “non-building assets” or “mobility assets” mean –
 - (i) any class of vehicles, devices or equipment that is transportable under the power of the applicable vehicle, device, or equipment by land, sea, or air and that consumes energy from any fuel source for the purpose of (a) that transportation or (b) maintaining a controlled environment within the vehicle, device, or equipment; and
 - (ii) any Federally-owned equipment used to generate electricity or transport water.
- (6) The term “secondary savings” means –

(i) additional cost savings that are a direct consequence of the energy savings that result from the energy efficiency improvements that were financed and implemented pursuant to an energy savings performance contract.

(ii) The term “secondary savings” includes, but is not limited to (a) cost savings that result from a reduction in the need for fuel delivery and logistical support; (b) personnel cost savings and environmental benefits; and (c) in the case of electric generation equipment, the benefits of increased efficiency in the production of electricity, including revenues received by the Federal government from the sale of electricity so produced.

4. Amend Definition of “Energy Savings” to Include Non-building or Mobility Assets

At 42 U.S.C. § 8287c(2)(A), delete the word “or” before “wastewater treatment” and then add “fuel supply, delivery, or transport,” and add, after “federally owned facilities,” “or non-building or mobility federal assets.”

Section 8287c(2)(A) as amended would read: “(A) a reduction in the cost of energy, water, wastewater treatment, *fuel supply, delivery, or transport*, from a base cost established through a methodology set forth in the contract, used in an existing federally owned building or buildings, other federally owned facilities, *or non-building or mobility assets* as a result of—”

5. Amend Definition of “Energy Savings” to Include Savings from Reduced Fuel Use

At 42 U.S.C. § 8287c(2)(A), add the following: “(iv) the improved efficiency of fuel use by non-building or mobility assets.”

6. Amend Definition of “Energy Savings Performance Contract” to include Non-Building or Mobility Contracts

At 42 U.S.C. § 8287c(3), after “locations,” add “or for the purpose of reducing fuel use, fuel delivery, or transport costs for non-building applications.”

B. Changes to Regulations or Policy

To achieve maximum energy cost savings from non-building or mobility applications, Congress and the Administration would need to consider possible changes to fiscal regulations or policies to allow various agency organizational units to contribute savings from reductions in fuel supply, delivery and transport, particularly for military operations. Applying the burdened cost of fuel use in peacetime or wartime theaters could significantly reduce the ESPC payback and shorten contract term. Additionally, an

allowance for verified secondary cost savings (e.g., from reduced maintenance requirements) to be applied as payment is also needed.

For hydroelectric dam rehabilitation, the fiscal statutes and related regulations to allow excess energy production to be used for payments would need to be considered. In addition, clarification may be needed in determining what constitutes “in excess of Federal needs” under 42 U.S.C. § 8287c(2)(C).

APPENDIX A

Study Authorization Text

Energy Independence and Security Act of 2007

Section 518. Study of Energy and Cost Savings in Nonbuilding Applications.

(a) Definitions- In this section:

(1) NONBUILDING APPLICATION- The term 'nonbuilding application' means--

(A) any class of vehicles, devices, or equipment that is transportable under the power of the applicable vehicle, device, or equipment by land, sea, or air and that consumes energy from any fuel source for the purpose of--

(i) that transportation; or

(ii) maintaining a controlled environment within the vehicle, device, or equipment; and

(B) any federally-owned equipment used to generate electricity or transport water.

(2) SECONDARY SAVINGS--

(A) IN GENERAL- The term 'secondary savings' means additional energy or cost savings that are a direct consequence of the energy savings that result from the energy efficiency improvements that were financed and implemented pursuant to an energy savings performance contract.

(B) INCLUSIONS- The term 'secondary savings' includes--

(i) energy and cost savings that result from a reduction in the need for fuel delivery and logistical support;

(ii) personnel cost savings and environmental benefits; and

(iii) in the case of electric generation equipment, the benefits of increased efficiency in the production of electricity, including revenues received by the Federal Government from the sale of electricity so produced.

(b) Study-

(1) IN GENERAL- As soon as practicable after the date of enactment of this Act, the Secretary and the Secretary of Defense shall jointly conduct, and submit to Congress and the President, a report of, a study of the potential for the use of energy savings performance contracts to reduce energy consumption and provide energy and cost savings in nonbuilding applications.

(2) REQUIREMENTS- The study under this subsection shall include--

(A) an estimate of the potential energy and cost savings to the Federal Government, including secondary savings and benefits, from increased efficiency in nonbuilding applications;

(B) an assessment of the feasibility of extending the use of energy savings performance contracts to nonbuilding applications, including an identification of any regulatory or statutory barriers to that use; and
(C) such recommendations as the Secretary and the Secretary of Defense determine to be appropriate.

APPENDIX B

History of ESPC in Federal Buildings

Energy Savings Performance Contracts (ESPCs) were originally authorized in 1986 amendments to the National Energy Conservation Policy Act (NECPA) of 1978 (42 USC8287). Congress created ESPCs as a tool for agencies to use in meeting conservation and efficiency goals for federal buildings. These goals were set forth in detail by various Executive Orders and directives that have cumulatively required federal agencies to reduce energy use by 2010 by as much as a third in comparison to 1985 usage levels, and were more recently enhanced by Congress in the Energy Infrastructure and Security Act of 2007 to require an additional reduction of 3% per year over a baseline of 2003 usage. Use of ESPCs accelerated with the promulgation of program regulations by DOE in 1995, the streamlining in 1998 of ESPC contracting into blanket Indefinite Delivery Indefinite Quantity (IDIQ) contracts, with pre-selected Energy Service Companies (ESCOs) and the issuance of OMB policy to support their use.

ESPC has been and increasingly will be a vital tool in efforts to reduce federal energy and water use, and its use in buildings is accelerating rapidly. In the first five years after being fully operational (1999-2003), ESPC accounted for fully half of federal spending to meet federal energy and water use reduction goals. Appropriated funds accounted for only 22% (the remainder is attributable to conservation spending by utilities).⁵⁵

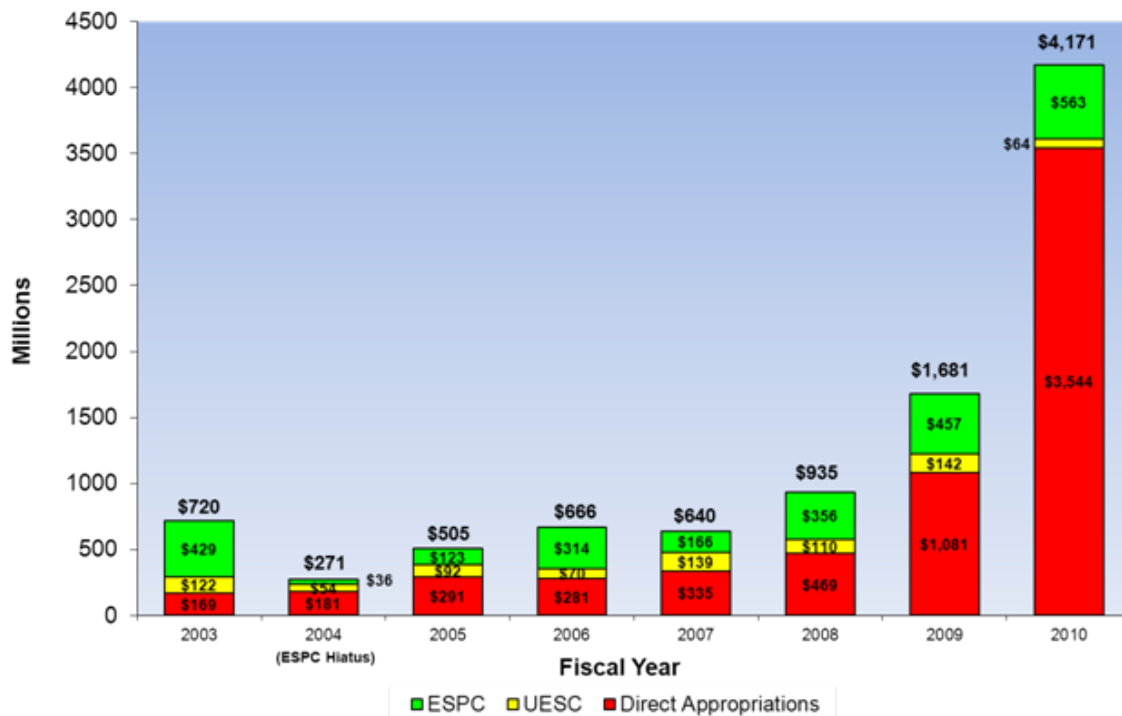
ESPCs are guaranteed performance-based fixed price contracts that allow federal agencies to upgrade obsolete capital assets and install and maintain energy efficiency improvements in federal buildings in the absence of capital appropriations. Private-sector ESCOs provide design services, construction management and financing for these energy conservation measures (ECMs), in return for payments to be made from a portion of the guaranteed future energy and water savings (for a contract term of up to 25 years). (Examples of ECMs include: new energy efficient lighting, building controls, operations and maintenance savings, boilers, chillers and renewable energy measures.) The federal agencies incur costs for procurement and project management that are similar than for a conventional bid-to-spec project, but do not incur the capital costs of the ESPC (unless they find it advantageous to leverage appropriated funds they would have otherwise have expended on a smaller portion of the scope of work).

By requirement of the authorizing statutes, the government never pays more than it would have paid for utilities if it had not entered into the ESPC for the term of the contract. In addition to generating energy, water and dollar savings, years of deferred energy related maintenance at federal facilities have been effectively addressed by the ESPC program.

⁵⁵Federal Spending by Funding Source to Meet Conservation Goals, 1999-2003
From: Federal Energy Management Advisory Committee (FEMAC); Energy Savings Performance Contracts (ESPC)-Report on ESPC authority; Sep 08, 2004

Despite a slow start, and despite a hiatus when the statutory authority lapsed due to a sunset provision, ESPC has made an enormous contribution to the federal government's energy-cost reduction goals. Spending on energy conservation in federal facilities plummeted when ESPC authority was allowed to lapse in 2003-2004, but the use of ESPC has sharply recovered – as of 2010 over a billion dollars in ESPC energy conservation projects are in development.

Figure B1: Federal Spending for Conservation Goals 2003-2010

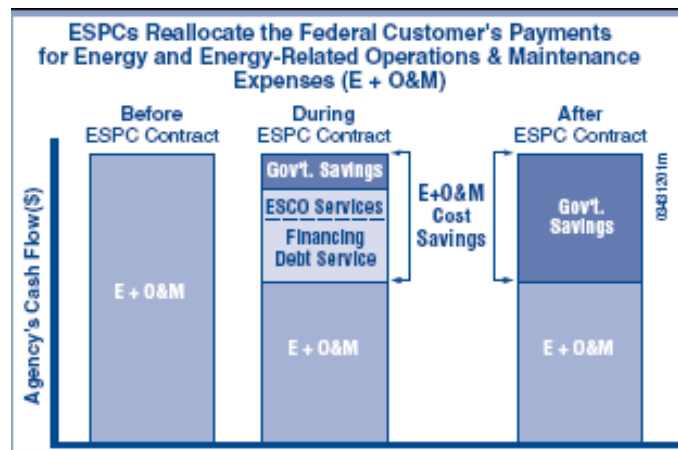


ESPC projects have been implemented by 20 different federal agencies and departments in 47 states, and for US facilities overseas. More than 500 federal ESPC projects, altogether worth \$6 billion in private-sector funds, have been awarded through FY 2011, with more than a billion dollars in additional projects now in development. These projects are guaranteed by their ESCOs to pay for themselves, with more than \$6 billion in energy and operational cost savings.

Without ESPC, the federal government would not be close to meeting the goals it has established for reducing energy and water use reduction in its facilities. There is great competition for the many potential uses of appropriated funds, and it is clear that sufficient funds have not been, and quite possibly will never be, appropriated to meet these goals. Despite the multi-year loss of momentum in ESPC due to the lapse of authority, and the modest increases in recent years of appropriations for federal energy efficiency, appropriated funds still account for no more than 30% of total spending.

But as important as energy efficiency is in this era of global warming, the significance of ESPC is greater than the reductions in energy use. It truly represents the conversion of otherwise inefficiently spent operating dollars into a revenue stream that would not exist without ESPC – energy and water costs would simply go on being paid. This revenue stream permits agencies to upgrade obsolete capital assets, reduce their backlog of deferred maintenance, solve occupant comfort problems and improve working conditions and productivity in their facilities – all without spending more than they would spend if they allowed their buildings to remain inefficient and unimproved. After the ESPC payback period, the government continues to reap all of the savings, freeing up even more taxpayer dollars to be used for other priorities. Figure B2 below graphically illustrates the Agency's cash flows before, during, and after the ESPC.

Figure B2: Agency's Cash Flows Before, During and After ESPCs



From Fed Energy Management Program; DOE/GO-102003-1744 July 2003